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THE VALUE OF RESEARCH WORK IN EDUCATION.*

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We often hear the opinion expressed that the modern methods of education do not produce as good results as the old-fashioned ones. Is this true, or is it but the croak of the pessimist? Be that as it may, the questions and discussions at such gatherings as this make it evident that our modern methods are not yet entirely satisfactory. Is the fault in the choice of subjects, or is it in the teachers and their training? What do we mean by good results? What do we ask our teachers to do for us, and for our rising generation? These questions seem to bring us to a consideration of the best methods of education.

The test of every educational system is the product which it forms. It should produce men who think and decide for themselves, men of action, who make their mark in the world, who succeed in whatever they undertake, whether the problem be scientific or social. It should make of the average man an intelligent, clear-thinking, truth-loving and cultured citizen. The object of education is to expand and train the mental faculties, to teach people how to think for themselves, and that discipline is the most valuable which makes us the most self-reliant, and enables us to make the best use of our reason and judgment with respect to all matters pertaining to our own welfare and that of the community.

In that delightful book, "Helen's Babies," the author strikes a chord which finds a response in every human breast, when he

*Abstract of an address delivered before the New York State Science Teachers' Association at Syracuse, Dec. 27, 1901.

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represents the three-year-old hero insisting that his uncle open his watch and let him "shee wheels go wound." For centuries that cry has gone up from the children of men. All are curious to peer into the machinery of the universe and learn, if possible, how and why the "wheels go round." There is a deep-seated desire in every child to find out the reason of things, and this spirit of inquiry should be fostered and developed; it is one of the first essentials in research.

The work of the school should connect with the child's previous interests, and continue the educative process of the earliest years, which is always of the nature of original research. The excellence of science, as a means of teaching people how to think, is no longer questioned. Even with a view to culture, science, when properly taught, is one of the best means of educating the highest faculties of the human mind. By proper teaching we do not mean the mere learning of a lot of scientific facts, but discipline in the methods of science. Mere head knowledge may do a man very little good; it is the habit of mind and the training in method that determines the character of the man. As an instrument of human progress the greatest value of science is manifested in scientific inquiry, or research, and no amount of mere learning, or mechanical skill, can take its place. The progress in science and industry is due to the spirit of inquiry and inventiveness developed by research methods of training, and these methods should be applied throughout the whole educational course of every individual.

What do we mean by the research method? We may define it briefly as being "The putting of related experiences together, and finding things out for ourselves." All education which attains its highest ends is of the nature of original research. In this sense, that is to say, of adding to our knowledge by our own efforts, we have all been, to a greater or less extent, engaged in research work since the moment of our birth, and there is no period in life when the research method is more accurately and successfully applied than during our early years. The young child learns the meaning of a word, tone, look or action by putting together various instances of its occurrence, forming a conception of its significance,

testing the correctness of this conception by repeated observations and modifying it as experience widens.

As we grow older and are able to understand the answers and explanations of others, our power of applying the research method seems to fall off rapidly. The ease with which we can then obtain information by asking questions, does away with the necessity for much mental effort on our part, and we gradually cease to investigate for ourselves, this power dying away with disuse like any other power. Moreover, we fall into the habit of appealing to, and relying upon, authority. The child should be placed under such conditions that his desire for the acquisition of knowledge can be kept alive and fostered, and so that he does not lose the habit of systematically searching for truth by the aid of known truths, and testing the validity of each step by constant reference to experience and experiment.

It is important that this power of applying the research method, this acquiring of science-forming ideas, should be raised to as high a pitch of efficiency as possible before we stand face to face with the problems of life. It becomes more and more difficult to begin to apply this method as we advance in years. It is unwise, then, to postpone its cultivation until we have entered upon the special duties of our life-work. It should be cultivated, as we have said, during the whole school career, from the kindergarten up.

Much of our modern education fails because many subjects, even the sciences, are learned as the dates of important events in history are learned; the memory alone is exercised; reason and judgment do not come into operation, unless it be merely to refer matters to some authority which is considered final. It fails, too, because the pupil is not trained to apply his knowledge. It is by constantly making practical use of the knowledge we possess that the power of original application of knowledge is best brought out. The pupil should test his knowledge continuously, and learn "to do by doing." In language study he should translate from one language to the other, until he has acquired readiness and facility in the process; in mathematics he must work problems, and in the sciences he must prove his theories by experiment. He

should use his knowledge and reasoning with respect to some phenomenon, and then test his ideas by experiment. The result usually shows him that his preconceived opinions must be modified, or perhaps wholly abandoned; that there are laws which must be discovered by patient labor and investigation. He realizes also, that he must be constantly on his guard against errors, that he must become acquainted with the sources of these errors and learn to fulfill the conditions necessary to avoid them. He may be able to learn a great deal about the truths and principles of science, and their experimental illustrations, by reading about them in a good text book; he learns more, if, in addition to the reading, he can see the experimental illustrations and demonstrations performed by another; but he learns most and best by doing them for himself. There is nothing that brings the truth home to the mind so well as experimental proofs carefully carried out for one's self. The possession of knowledge does not confer upon a man the ability to use it, and the possession is of no value if it cannot be used and applied. If our one talent is to gain other ten talents, it must not be buried in the earth.

That knowledge which we have acquired by serious thinking and hard work we are apt to value and remember; it becomes, at least, a more secure possession than that which has been easily and lazily gathered while enjoying a cigar and fan. The difficulty of a book, or subject, is not in itself an objection to its use in education, for to learn how to overcome difficulties is a very valuable part of the training. Mathematics are hard, and Greek is hard, and that is one of the reasons why they are such excellent educational subjects. In the present day, however, when there is so much to learn, we are always on the look-out for the "Royal Road," and even when we have done our best to smooth the way, there is considerable difficulty left.

Our modern system of education should stand out against the abuse of authority and memory. The lack of time, and the necessity of mastering a certain amount of information in which examinations have to be passed, are perhaps the main causes of these abuses. Examinations, as they are usually given, test only the memory, not the powers of reasoning and judgment.

Culture does not depend so much upon the subjects, as upon the method and persistence with which they are pursued. It is no argument against the study of the classics, that the proper study of science makes keen thinkers and able men, for the classics properly pursued will do the same; nor, on the other hand, is it any argument against the sciences that the classics have produced the profound thinkers and eminent scholars of the past. Who will ever know how many thousands there were, during the past centuries, who had no love for the study of classics or mathematics, and who had no opportunity to test the educative power of other studies?

It is estimated that about two per cent of all boys are clever, and for a clever boy any subject of study is good enough, one perhaps as good as another, if it enables him to come into close mental contact with great thinkers. But what about work for the other ninety-eight per cent, the average boys and the dull boys? The study of the sciences proves to be the intellectual salvation of many of these. It arouses some minds which nothing else seems to reach, and it develops and trains, in all cases, faculties which otherwise would have remained dormant.

Progress is always greater when the work is pleasant, and there are so many ways of study offered by the sciences that one has a chance to select that which is most attractive for him, and instruction from the teacher need not change or hinder his own natural method of study. Some branches are almost purely observational; but, if he prefers abstract reasoning, he takes up the mathematical side; or, if he loves to make apparatus and use it, he approaches the subject on the experimental side.

A two-fold advantage is claimed by the advocates of science studies; first, that they are a means of the best mental training, and, secondly, that they communicate a kind of knowledge which is of practical use in everyday life. It has been said that the teaching which limits the range of a man's vision to the subjects and facts of which he can see the use does not deserve the name of education, the very essence of which is the strengthening of the intellect by mental exercise. But in these days of fierce competition in the industrial world, we must study more and more those truths and

principles of abstract science which lie nearest the useful. There are many problems in nature the solution of which would confer great material benefits upon mankind in general, and in which the processes and methods involved in carrying them to a successful conclusion are identical with those which the problems of pure science require, while the discipline and training imparted are equally good. I am not encouraging the idea that utilitarianism should be made the end and aim of education; but what is the advantage of, for instance, making a close study of the planet Mars, its markings, its climate and its physical conditions, when we know little or nothing of the composition of the earth's crust, or of water, or air, or the glass in our windows, or what the nature of the light is that shines through them? The widest culture is the noblest culture; universality and thoroughness may go together, but why do we so often go far afield for subjects for investigation and study, when there is much that is just as good near at hand, and perhaps more likely to prove useful in everyday life?

There is a kind of knowledge that is actually becoming a necessity. It is that knowledge which best unlocks nature's storehouse, and enables us to wrest from her more than has ever been obtained before, that knowledge which will enable us to find out and use powers of nature which have never been used before. The great success of Germany in commerce and manufactures is due to the particular attention paid to the physical sciences. Sooner or later knowledge and method and industry must tell. Dr. Lockyer, the English astronomer, said, recently, in an address: "I look upon scientific education as a great and necessary line of defense for our country, perhaps scarcely secondary to our naval and military forces."

The connection between scientific and technical education is a close one. In the laboratories new discoveries are constantly being made, science makes known to us new properties and qualities of matter, and mechanical invention applies these discoveries to industrial processes. A thorough training in abstract science is a necessary groundwork for a technical education, for how can one understand the practical applications of a science unless he is familiar with the underlying principles of that science? To spe-

cialize without the proper preparation is like building the top story of a house first, when it is completed you have but a one-story house, and it sits on the ground.

The applied science of the future is now in the process of formation in the operations of those who are working in pure chemistry and physics. Thousands of investigators are patiently working in the laboratories in all parts of the world to bring out new knowledge, and each year now witnesses more discoveries than a century used to. A renowned painter was once asked which he regarded as his greatest painting; he answered "The one I am about to paint." The greatest discovery in science is "The one that is about to be made." The best teaching inspires the student with the conviction that he also can work out new truths, and make some permanent additions to human knowledge.

A scientific man, as such, is valuable according to the amount of new knowledge he is able to bring out, or if he is not engaged directly in research, according to the number and ability of the workers which he prepares and equips for the bringing out of new knowledge. We lead in the struggle for commercial supremacy among the nations of the world, partly because of our great natural resources, but largely because we have such a good supply of investigators and well-trained managers, and workmen competent to take instant advantage of every discovery in science. We must maintain, or even increase, the number and efficiency of such men, and must afford them the facilities for acquiring the necessary scientific knowledge and training. The investigators and managers, perhaps, receive their training in the universities or technical schools, but the workmen, who should be sufficiently well-trained to take the initiative whenever necessary, must depend entirely upon what they receive in the public and high schools. If in these schools they are taught to understand and apply the best-known general principles they will be able later to master a given set of practical details with readiness and facility. To the science teacher, then, belongs in a large measure, the task of preparing all these, so far as education is concerned, for their work in life. Every teacher who teaches science thoroughly is training skilled teachers for the rising generation. He should have, not only a thorough

knowledge of his subject, but the ability to impart that knowledge to others, and the willingness to do his utmost.

It is, of course, indispensably necessary that he should be well grounded in his work, and should have a thorough comprehension of the methods and principles of his branch of science, but there is, for the teacher, even though a specialist, a great value in general culture. The man of broad culture and refinement seems to impress his ideas upon the pupil's mind in a way that makes them stick. The teacher who knows his special subject well, but not much in other lines has difficulty in doing this. The two-fold caution so often given by Bacon against over-generalization on the one hand, and against over-specialization on the other, is still as deserving as ever of the attention of mankind.

A recent writer says that science is ever seeking to write in pure symbols, hence it is not comparable with what we understand by literary work. Some of the grandest truths may be presented to the mind by means of pure symbols.

There are truths which cannot well be expressed in any other way. It is said that Newton, after waiting for years to secure accurate data, was so overpowered by emotion, as he neared the end of his calculations, that he was unable to finish them, but called another to do so for him. Yet what Newton saw was a few pure symbols, a simple arithmetical expression. But that simple expression revealed to him the fact that every particle of matter attracts and is attracted by every other in the universe. He was thrilled by emotions which language is powerless to express or describe. Have you ever gazed upon a scene of such grandeur and magnificence that you realized that language was perfectly inadequate, that you could not even attempt a description of your feelings? Then you may understand what he felt.

Speaking now more especially concerning the value of research work proper, we might consider first, the perceptive faculties. One of the first things the student in scientific research must do, is to learn to use his eyes. He must be an accurate observer of the various objects and phenomena with which he is concerned. A great deal of our knowledge, if we are to profit by the labors of others in the same field, must come from books, but we should

insist that the learner be taught to observe for himself before he appeals to the experience of others. The ancients seem to have been particularly deficient in the power of observing. They gave much attention to astronomy but they record the number of fixed stars visible to the naked eye as 1600, while we now give the number as nearly 4000. We also give about 20 as the number of nebulae and star-clusters visible in our latitudes, while Hipparchus gives two and Ptolemy but five, both of them omitting such remarkable objects as the nebulae in Orion and Andromeda. The constellation of the Pleiades was considered of great importance for navigation and was constantly observed, and yet only seven of its stars were discovered. In fact the seventh one was lost sight of for centuries, and ultimately when the middle star in the tail of the Great Bear first attracted attention, the conclusion arrived at was that it was the missing 7th star of the Pleiades. Nowadays cases are known of people who are not astronomers seeing from 14 to 16 stars in the Pleiades, and it is by no means uncommon for people of good sight to see 11. The star Alpha Capricornus was seen by man for thousands of years without it being noted that it was a double, a fact that any child would discover now, if its attention were directed to the star. It would be interesting to know in how far we inherit a trained eye from generations of ancestors who gradually accustomed themselves to the accurate observation of objects. In addition to training his perceptive faculties, the student in research must exercise his reasoning powers to work out and understand his observations, and systematize them, and compare them with others. In science we are much more concerned with the quantitative relations than with the qualitative, and as our knowledge increases that part of it which is mathematical also increases and becomes in many cases quite difficult. In planning and conducting operations in research work there is abundant opportunity for the development of the constructive imagination, originality of mind, and inventiveness. He must change his apparatus and appliances to meet the requirements of the problem in hand, or perhaps devise and construct new pieces as he amends his processes. Patient industry and self-denial, which are the first conditions of scientific investigations,

develop self-reliance, and impart strength and solidity to character. With what wonderful patience and perseverance did Kepler work! For 22 years he read the face of the star-lit heavens, tracing and measuring with patient exactness the positions and paths of his celestial wanderers, before he was able to deduce from his results the laws of their motion. Every notable scientific achievement rests upon a long-continued series of patient observations.

Research work calls into active play the powers of the imagination. A noted critic has said that the two men whose imaginations were the most brilliant of any of their day were Michael Faraday and Charles Darwin. All the phenomena with which the scientific investigator deals are concerned with the actions of the invisible and unseen upon the visible. There is force, energy, electricity, the universal ether, and many other such subjects or conceptions to consider and explain or describe, and the imagination is often unequal to the tasks imposed upon it.

A French Bishop, who had become greatly troubled over the nebular hypothesis, or the six literal days of Genesis, or something of that sort, preached a sermon in which he inveighed fiercely against science and scientific men, with a repetition of that condemnatory vigor which landed Galileo in prison. At the close of the service a noted astronomer went up to him and said "Monseigneur, have you never seen God?" "No," said the surprised Bishop, "I never have." "Then, your Grace, I have," was the reply. "I have seen Him in the great cathedral of the universe, I have felt Him in the movements of creation, I have witnessed His workings from nebula to star and from star to planet, I have read those Scriptures of the sky which you have not, I have touched His robe and know Him as a visible being."

In research work our ideas are of value only so far as they are true. Perfect frankness and truthfulness of mind are indispensable to success. Each new problem must be approached with the mind open for the reception of new truth, and all preconceived opinions must be laid aside or held subject to revision. It often requires the utmost skill and attention to sift the truth from the error. One must be careful and accurate both in measurements and statements. Extreme accuracy often leads to valuable discov-

eries. The discovery of the aberration of light would not have been made if Bradley had not been able to measure accurately to 1-100 per cent. To the fact that Rayleigh was not content to allow the small discrepancy of 1 part of 10,000 to pass unnoticed, the discovery of Argon is due.

Scientific investigation trains in mechanical operations, in manual dexterity and manipulative skill. There is constant adjusting and handling of apparatus, and many operations which are apparently easy, require a deftness and accuracy of touch which comes only from practice. Research work strengthens the memory, for the investigator must remember a large number of facts, and their mutual relations. It brings home to the mind of the investigator the fact that he must stand entirely upon his own merits. Credentials, certificates and diplomas avail him nothing. He realizes that they are no more than the stamp upon a coin, which makes it a counterfeit, unless the metal itself be genuine. Lastly, research is one of the most vital factors in the promotion of civilization, one of the most powerful levers of national prosperity and influence. Time will not allow, if, indeed it were necessary, to call attention to the wonderful discoveries of even the past decade. And yet how many of us think of the latest discovery as if it were really the very last that can be made. Research will never proclaim any proud period and her work accomplished, it grows from more to more. The good ship "Discovery" is well under way and the ocean of triumphant progress in unbounded.

METHOD IN SCIENCE TEACHING.*

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A man's power depends on three things; his native ability, his environment, and his education. It is only the latter that can enter into a discussion on method.

Much has been said about what education is, but of all its alleged components I regard two as adequate,—informing and training. Education begins with the first of these almost solely, being, later, supplemented by the second. The child's earliest acquirements are impressions and these become information stored in the mind, to be followed by the discipline of later school years and experience in life. This, too, has been the natural method in the growth of education.

The humanities being the earliest knowledge possessed by man, naturally formed the first material for an education and were simply acquired and handed down, exercising chiefly the memory and requiring little effort except attention on the part of the recipient. There was little exercise of thought, little comparison, judgment, or conclusion. Even the faculties of attention and retention were pampered by repetition, this feature giving rise to the Jesuit maxim, *"Repetitio est mater studiorum."*

When progress enough had been made in science to win for it recognition as one of the elements of an education, it was imparted by the method employed in the teaching of the humanities, and there was no distinctive method in science teaching. The deductive sciences, philosophy and mathematics, were the earliest taught and continued to employ largely the same method for a long time after experimental or inductive science became independent enough to break away and use its own method.

A part of the real value of the laboratory method—observation at first hand—is gaining knowledge by experimentation; and this is the practical application of the syllogism of philosophy which has been the classical method of mind training. The labora-

*Condensed from a paper read before the Detroit Principals' Association, April, 1901.

tory method has given us this most efficient way of learning facts of science, making them a part of our knowledge instead of parroted wisdom. But experiments teach not only facts and principles; they also train, and give power to find new data and laws, and so contribute to human knowledge.

Not only the mind, but the avenues of the mind must be trained. Manipulation, observation, reflection, comparison, judgment,—all must be exercised. Because the student *himself made the experiments and observations* in specially fitted rooms, called laboratories, instead of *being told about them* in lecture halls, this method of natural science study came to be called the laboratory method. Its first introduction into schools was in connection with biology, and in England, Huxley, and in this country, the elder Agassiz, were its champions, to whom it owes much.

Theoretically this method is the re-investigation of causes, facts, principles or laws that underlie natural phenomena, but re-investigated under instruction and guidance, the most favorable circumstances that can be imagined. So the process is a stimulating one, if the material is adapted to the age of the student in such a way that his powers are constantly exercised but not overtaxed. For early education it has the advantage of proceeding from the concrete to the abstract, from the simple to the complex, from the known to the unknown—following the order of the developing mind.

Practically it has been much abused by instructions and directions given in such a way that the student becomes a mere verifier,—an intellectual drone,—asking "What is to be seen?" and "What conclusion is to be drawn?", instead of being encouraged to a much needed independence.[2] There are at present several idealists: Those who tell nothing; those who direct the student in such a way that he can independently find the important data; those who tell all. The last are usually the old school scientists who hold, for instance, that the student must first learn the laws of gravitation before he experiments with falling bodies. They object that there is not time for rediscovering principles or laws that scientists have spent a long time in understanding. But we

(2) Dr. W. F. Ganong's Laboratory Course in Plant Physiology, 1901, of which notice was given in the November No. of SCHOOL SCIENCE, is a model book in this respect.

answer, that the man who discovers something, in order to do so, must have had more power than his fellows and he has developed this power along his line of discovery by slow increments. May not the student, by this very method, gain a power which will carry him far in advance of the point he would have reached by the old didactic method of science work? It is not so hard now-a-days to get an affirmative answer, since it is generally conceded that even in secondary schools discipline is more important than the amount of knowledge stored. The latter may be forgotten or misapplied, but the former gives power to reproduce forgotten facts or to find new ones. But before giving power, laboratory work begets a habit of thoughtful and accurate observation, careful consideration of all phenomena or facts—a most important preliminary step in all education.

Now, while it was said no more time need be given for finding facts and rediscovering principles than required for another lesson, this means a lesson of equal value. It is important in the laboratory method to give time enough for each experiment to understand fully the factors included, separating those not touching upon the question from those involved in its decision. The next step in the process is the comparison of facts observed, or the results of an experiment with those of another experiment or with some experience. All this is necessary before the final step, the drawing of the conclusion. Here we see a striking difference between this and the informational method. In the latter nothing further is required than to receive, and apply (?) that which is received. And when students in our schools learn to acquire things by the laboratory method they are doing what advanced scholars used to do, and in so far our present system is ahead of the old. Is it surprising that students have to be urged to compare related facts and draw conclusions when it is adult nature to follow prejudice rather than facts and their consequences?

Going a little more into detail of the method in natural science teaching, we may say it is the easiest one to follow. In the first place, it is the observation and comparison of the evident phenomena in nature, and this is akin to analysis. Thus to learn the use of fleshy fruits, these are examined, and it is observed that

all fleshy fruits have some food material, bright colors and agreeable odors and flavors, which can be of no direct use to the seeds they contain. These have nearly the opposite qualities. Now, when it is asked what will happen if an animal, attracted by these inducements, carries away and eats the fruit, the inference (synthesis) that the seeds because of their qualities are rejected and thus scattered, leads to the larger truth that fleshy fruits are solely for the distribution of seeds. This general method of observation of things themselves, comparison and inference, has been found so valuable that it is no longer employed in science alone, but also in other studies, being used to some extent even in language teaching. While the observational method in general has been applied to other studies, the experimental method can be used in science alone.

Since not all of nature's processes are open for inspection of cause and result, a large number of phenomena must be determined by what is known as the method of experiment,—that is by modifying the natural conditions in such a way as to get definite or special results, and from these artificial conditions to obtain facts or data from which the natural processes can be inferred. As the experiment is so important both in science and in science teaching, and has been so much perverted, it may be well to go more into detail on this part of the subject.

Some one has said "An experiment is a question put to nature." Another view is, that an experiment modifies the conditions of nature in such a way as to show what are the natural phenomena. This seems to me more comprehensive.

I believe it is the consensus of opinion that an experiment is a test or trial to find out something; and since it is to reach some conclusion it is in the nature of a syllogism and must embody two premises. If this is true, a moment's reflection will show that a great many so-called experiments in our text books are merely illustrative or confirmatory. This is always the case where the proposition is stated first, or where the object of the experiment foretells the conclusion. Such experiments might as well add the "*quod erat demonstrandum*" of our geometries.

In order to determine any point by an experiment we must

have two sets of facts, one of which may be the conclusion of a previously performed experiment. Thus if the learner is to test unknown substances for starch he must apply iodine, not only to the substance, but also to some known starch. In the student's training it is very important that this step be taken; simple though it seems, it is fundamental for inculcating accuracy. After the experiment has been observed a sufficient length of time we have two distinct results, and by an act of comparison and judgment from these two, the thing to be found out, or conclusion, is drawn. Accordingly, the chief points of an experiment are conditions, results, and conclusion.

It is the experience of nearly every teacher that the pupil remembers the apparatus better than he does the essentials of an experiment, better, even, than the conclusion. Having learned by experience that the apparatus impresses itself on the pupil's mind to the detriment of the real principle, the teacher would better have him describe only the conditions as brought about by apparatus, operation, or any modification of natural conditions. This has another advantage; it does away with the necessity of describing the object of the experiment, in which operation, very frequently, the conclusion is too nearly hinted at, and the pupil becomes a verifier instead of an independent observer.[3]

Another great difficulty is in getting the student to see clearly the difference between the results of the modified conditions and the conclusion that can be drawn from such results. He often states the conclusion and gives it as a reason for the result or he cannot get any conclusion at all. Frequently this is because the experiment takes into account experiences that the student has not had. On the whole, it is a lack of perception of the relation between cause and effect and is a part of the student's training that needs serious attention.

All this can be remedied by patient questioning, shifting premises, etc., but a better way, I believe, is to give some simple experiments leading up to the one in question, or, it may be, several different experiments leading to some of the most important

(8) Out of many high-school textbooks on science that I have seen only two are practically free from this fault of "giving away" the conclusions of experiments.

principles to be fixed. There is another value in giving more than one experiment, and that is, more perfectly clinching the fact or principle taught, to say nothing of the discipline. It will lessen the tendency of placing the apparatus in the foreground, since the final result is obtained with different apparatus. It will also do away with the temptation to make experiments easy by prefacing them with, "to show so and so," in which case most students, even when the experiment fails, will draw the prefixed conclusion. This is pernicious, as it changes the experiment into a mere illustration, warps, by its insinuation, the pupil's too plastic judgment, and lessens his independence.[4]

The making of several experiments for one conclusion also recognizes the time element in education. To grasp any idea well, the young mind, especially, must have time in proportion to the difficulty of the idea; but the time is not profitably put in if the idea is beyond the experience of the pupil. Here, again, there is danger that the pupil will be carried along by the teacher instead of being allowed to pick his own way. To do this independently a few simpler experiments can be given as preliminaries, leading up to the principal one. To illustrate: a test for oil in seeds should be preceded by an experiment on a seed known to contain oil; the experiment for starch-making in leaves should be preceded by the test for starch, then by an experiment for starch in a normal leaf, then by one on an etiolated leaf.

Naturally the lack of school time for this method will be the overwhelming objection urged by all. But since this kind of training and the knowledge gained is so fundamental, the old adage of "a stitch in time" was never truer than the assertion that right here the pupil's whole intellectual future is at stake. He would better take time at first to save it at the last.

The application of the science method in primary schools might begin with nature study in the grades, and for this it would be best if we did not study any special science but some part of nature as a whole. It would be most profitable if the study were largely observational, few inferences being drawn until many data

(4) Professor N. A. Harvey (SCHOOL SCIENCE, Vol. 1, No. 3, p. 121) records similar experiences.

are at hand. The observations may be along the line of experiences rather than experiments, at first; thus, instead of making experiments, as is done in the high school, for determining the conditions necessary for the germination of seeds, let the pupil simply place seeds in favorable conditions and watch them germinate and grow, thus realizing that they are alive and can do something.

External general observations as to form and parts are simple and easily made and may lead to simple inferences.

In the higher grades general relationships and some classification of phenomena would give a bird's-eye view and prepare for the studies following.

Some of the easier parts of physical geography might be taught in the eighth grade. This should be followed by the more difficult parts of the same study in the ninth grade, by botany, zoölogy and physiology in the tenth grade, by two courses of chemistry in the eleventh grade, and two courses of physics in the twelfth.

It is not an infrequent complaint that the work in science does not show for as much as that in the languages or mathematics. Is this to be wondered at when the pupil begins the latter studies with his entrance into school and continues them through his whole course, while he may have anywhere from but one to three terms in science? And his science teacher frequently has this as an adjunct to several other studies. How can such a teacher be expected to practice any particular method or make any strong impression on his pupils?

To give natural science studies and their method of educating a fair chance would mean consecutive and logical arrangement of things studied from the first grade up; continuousness or sequence to be followed out through the whole school course even if only a small amount of time be given daily.

BIOLOGY IN AMERICAN COLLEGES—ITS METHODS AND OBJECTS.

BY FRANKLIN W. BARROWS.

A few months ago, the writer addressed a series of questions on biology to half of the colleges and universities of the United States, selecting those having the most complete equipment. Nearly one hundred replies were received, representing the largest and best known universities as well as some of the smallest and most obscure colleges. Although these one hundred institutions are only a quarter of all our schools devoted to the higher learning, yet, for the purposes of this inquiry, they may fairly be called representative, because they constitute fully half of all the institutions in which the biologic sciences receive any special attention.

It is because a hundred college and university professors here speak of and for themselves, that this medley seems worth printing. Many of the replies are quoted verbatim. Others are summarized in the discussions following each question.

Question I.—What feature of biological study do you try to emphasize in your institution?

"Fungi and insects as related to plant diseases."

"First—Accurate morphological work. Second—Study of theories, critical, analytic and synthetic."

"I give a laboratory demonstration of every principle taught in class. I am emphasizing personal contact with nature."

"The study of the phylogenetic development of the animal kingdom as culminating in man, and the parallelism of man's ontogenesis."

"The practical knowledge of vital phenomena from the zoölogical side."

"We give more attention to structure than to classification."

"Anatomy, morphology, and taxonomy of plants."

"1. Function. The work of species—interrelations. 2. Physiology. 3. Neurology. I am strongly on the side of activities, functions, etc., because therein lie most of the larger human values; and, where this point of view is not held, the work has little solid quality. It needs the human interest to put common sense into it, and the idea of change as activity goes through its various phases to make results really logically consistent."

"For our first year's work we look at forms from the standpoint of their relation to the outside world. Laboratory work is emphasized."

"(a) General significance to educated men. (b) Importance of research."

"1. In the undergraduate courses in general, biology as a culture study in the training for the broad problems of life and the duties of life. 2. Specifically, in the advanced courses, comparative neurology is emphasized (anatomy and physiology)."

"We try to bring out the educational value of biology as a factor in a liberal college course and at the same time give the student a foundation for more advanced work."

"General study of types, preparatory to advanced work in zoölogy and palaeontology."

"Comparative morphology and general physiology."

"Laboratory work. I try to teach the students to attain a certain technical skill in doing delicate work. My students intend to study medicine, and human morphology is constantly brought before them."

"Contact with things, study of types, and then extensive reading from good library."

"Principles of comparative morphology and embryology."

"Ecological and physiological—(natural history.)"

"A thorough grounding in the *elements* of the work."

"The morphological side."

"1. Its disciplinary and informational value for students who will later study medicine or who will teach science. 2. Its general cultural value for other classes of students."

"I endeavor to train students to study for the sake of finding out."

"Relation of insects to agriculture."

"Assuming that you refer to *educational feature*, the zoölogical department lays stress on its peculiar disciplinary value. Along research lines we are developing experimental zoölogy and fresh water biology."

"Cytology and histogenesis in both botany and zoölogy."

"The study of living animals and plants."

"Physiology, in a broad sense."

"Considerable time is given to morphology, but physiology is the side we emphasize."

"Animal morphology."

"The acquisition of knowledge at first hand, for the student; a critical comparison of his own results with those of his predecessors in the same field, for the investigator."

"The morphological feature in zoölogy."

"Zoölogy is unfortunately unduly emphasized, simply because the professor is a zoölogist. Comparative anatomy or morphology receive most attention."

"The anatomy of mammals and the origin and relationship of the various groups of vertebrates."

"Ours being an agricultural state we emphasize the economic in zoölogy and entomology, but give as much of the purely scientific as possible."

"Broad scientific culture without 'features'."

"Botany, entomology."

"(1) General biology as the introduction to fundamental physiological principles. (2) Zoology."

"Botany and invertebrate zoölogy."

"The morphological side of both botany and zoölogy is emphasized at present. Embryology is prominent, also neurology."

"Biology as it finds practical application in bettering humanity. The morphological and physiological."

"Morphology of animals."

"Applications to agriculture in agricultural college. To medicine, for students preparing for medical college, and in all work the actual study of typical forms in field or laboratory."

"Morphology is perhaps emphasized; try to round out the corners as far as possible rather than to specialize."

"Comparative morphology and general physiology."

"Such biology as has been taught here has been of the old-style-text-book variety, and little or no laboratory work has been attempted. The students have been given some opportunity to prepare microscopic slides, but I cannot learn that they ever studied them."

"One man can do little if he spreads over the whole field of biology. I am trying to do something in botany."

More than 25 per cent of the institutions reporting teach all the biologic group of sciences, emphasizing nothing. It is noteworthy, however, that some of the leading universities did not hesitate to report one or more "specialties," while most of the small colleges made no pretence of covering the whole field. The branches most emphasized are: Animal morphology, 25 per cent; botany, 17 per cent; general biology, 15 per cent; physiology, 15 per cent; zoölogy, 11 per cent; embryology, 7 per cent. One tenth of the colleges pay special attention to preparation for medical courses. Two colleges aim at preparing the student to teach, and one prepares for agriculture. Three schools specialize in ecology, four in entomology, two in neurology, one in vegetable pathology, one in "phylogeny," and one in the study and comparison of the various biologic theories. The marine fauna of the Pacific receives special emphasis in one university, the biologic survey of lakes and caves, in another, while a great technical school offers special opportunities in sanitary and industrial biology. Finally, five colleges and technical schools out of the whole have either no biology at all, or no more than the average high school.

(*To be continued.*)

CORN OR GLUCOSE SYRUPS.

BY EDWARD GUDEMAN.
Chemist and Chemical Engineer, Chicago.

Corn or glucose syrups are mixtures of sugar syrups with glucose. The different grades are made by varying the proportions of sugar syrup and glucose. The color and taste of the mixed syrup depends on the color, taste and amount of the sugar syrup used, as glucose is water white and has no characteristic taste, except being sweet. Beet sugar syrup is not used straight to any appreciable extent, on account of its peculiar bitter taste, which cannot be fully hidden by the use of flavors. When used it is only to replace part of the cane sugar syrup and in the lowest and cheapest grades of corn syrups. Refineries working up cane and beet sugars, turn out low grade syrups. The quality of the sugar syrup depends on its taste and contents of actual sugar. The proportions used vary from 5 per cent to 50 per cent. To get special color or taste, sometimes as high as five different kinds of sugar syrups are used to prepare the mixed syrup. Sorghum syrups are mixtures of straight sorghum syrup, cane syrup and glucose. Most of the molasses contains glucose, although quite an amount of the straight goods are found on the market. Straight molasses is the cane sugar syrup direct from the plantation, without having been purified or refined. As molasses is very often bleached, it must be examined for mineral salts, especially zinc and tin, and if found to contain any, it should be rejected as unwholesome. Molasses bleaches very easily, and the best test is to bleach a sample, and if it does not react strongly and quickly, it can be suspected that it has been previously bleached. Maple syrups should be the straight concentrated sap from the maple. The use of glucose to make maple syrups is a very common practice, and if used in small quantities cannot be detected by the chemist. Pure maple syrups can contain up to 25 per cent of reducing sugars. A good flavored maple syrup can be mixed with 10 to 15 per cent of glucose and 10 to 15 per cent of dissolved cane sugar and not be distinguished from

the pure article. Syrups flavored with bark extracts and with maple flavors are in the market, to a very limited amount, but will never be mistaken for the genuine maple syrups. There is no question as to the wholesomeness of straight corn syrups. The addition of glucose to the raw sugar syrups materially improves them and makes them palatable, while in the impure state they would not be fit to be used as a food article. As regards pure glucose, there is now only one opinion, and that is that it is fully as healthy and as nourishing as cane sugar and much more easily digested. Sugar is changed into glucose by the action of the saliva and the stomach juices, and when so changed does not materially differ in its character and actions from the pure commercial glucose.

Not all table syrups are straight mixtures of sugar syrups with glucose. They contain various substances, some unwholesome. The most commonly used ingredients in table syrups are: Saccharine, natural and artificial flavors, caramel (phosphoric, muriatic, sulphuric or citric acid), antiseptics, especially bisulphites of soda or lime, vanilline and cumarine. A careful examination of the literature pertaining to these substances show that the ones that can be considered as directly injurious are the acids, the antiseptics and saccharine.

The manufacture of saccharine or its importation, except for medicinal purposes is prohibited by Germany, France, Belgium, Austria-Hungary, Switzerland, Italy, Portugal, Brazil and Spain. Some of these countries allow its manufacture for exportation.

Sulphurous acid and its salts are absolutely prohibited in Germany and Switzerland, and very strong restrictions placed on their use in food products by Russia and England. All substances that have strong antiseptic properties will continue to assert these properties after being taken into the stomach and must naturally retard the natural functions of digestion. The use of the artificial flavors or essences is a very bad thing, and it is to be deplored that they are so extensively used in syrups, jellies, candies, ice cream and carbonated waters. I have not been able to find any direct references against the use of such flavors and essences, and base my view on their composition. They are concoctions of ox-

ides and ethers of acetic, amylic, valerianic, butyric, oenantic, benzoic, salicylic, formic, tartaric, citric, lactic, and malic acids; others contain spirits of nitre, ether, chloroform, glycerine, fusel-oil and various alcohols. The chief constituents are amyl acetate, fusel-oil, glycerine, alcohol and some coloring matters. As all of these substances have strong medicinal properties, they can be considered as injurious in food products.

The composition of two flavors gives a good idea of the whole class.

Nectarine.—The pure flavor should be an alcoholic mixture of raspberry extract and vanilla. Analysis of the commercial article showed spirits of nitre, amyl acetate, glycerine and saccharine. 3.2 per cent. of solids, 0.03 per cent. of mineral ash, and about 70 per cent of alcohol. The price was $6.00 per gallon.

Chocolate Flavor.—The pure flavor should be an alcoholic extract of the cocoa bean. Samples examined contained no cocoa extract, but contained glycerine, ethers, and caramel. Total extract, 4.2 per cent.; ash, 0.22 per cent.; alcohol, 60 per cent. Selling price, $9.00 per gallon.

The price is no criterion of the quality of the flavor, as it is possible to make and sell a pure flavor at a few cents above the value of the alcohol which it contains. In two cases wood alcohol was used, and such flavors I consider as downright poisons.

Vanillin and cumarin I do not place into the same class with the artificial and imitation flavors. These synthetic products seem to be identical with the aromatic principles extracted from the tonka and vanilla beans. No statements have been found showing that these two flavors are in any way to be considered as injurious when used in food products. Vanilla is adulterated with acetanilide. Its purity can be quickly determined by taking the melting point. Cumarin is very seldom used as a straight flavor. It is added in small quantities to the vanillin flavor, it being claimed that this brings out the flavor of the vanillin; I have not found this to be the case. The addition of cumarin brings up the percentage of extract at low cost as compared with vanillin. Very little, if any, pure vanilla bean extract is in the market today.

This statement is liable not to be accepted, especially by manufacturers, but it is an actual fact that the vanilla extract at a cost of $4 to $5 per gallon contains 2 to 3 times the amount of vanillin as found in such extracts 10 years ago. The cost of alcohol has increased and the cost of the raw bean has not materially changed in cost or contents of extract, so the increase of vanillin must be accounted for by the direct addition of the same to the bean extract. Vanillin flavor is the most extensively used flavor of all and I believe that fully one-half of the flavored syrups contain it.

Caramel or sugar colorings are perfectly harmless if made without sulphuric acid. Some very low grade syrups consist of 98 per cent. glucose and 2 per cent. caramel. Such syrups differ from pure glucose only in color and have no characteristic taste.

China clay is mixed with syrups with the purpose of creating the false impression that the syrup contains a large amount of sugar, the cloudiness due to the sugar being imitated with clay. The use of China clay or other inert body to create such an impression is a plain case of fraud and deception. The quantity used is small as one part of clay to 600 parts of syrup gives a very distinct cloud.

Acids are added to syrups to give a peculiar tart taste, especially for sorghum syrups and molasses mixtures. No doubt the use of muriatic and sulphuric acids should be prohibited. Whether the same applies to phosphoric acid, it is hard to say. It is very extensively used, especially with carbonated waters, and I have found no direct mention of any injurious effects. Preservatives are absolutely not necessary to protect syrups against fermentation. They are very commonly used, however, especially salicylic, benzoic, boracic, hydrofluoric, sulphurous and sulphuric acids; sulphites of soda or lime; borax, phosphates, formaldehyde, etc.

The fact that corn syrups are consumed in very large quantities by all classes, young and old, in many cases forming a large part of the daily food supply, makes it absolutely necessary that the syrups should be pure and free from all deleterious substances. It is immaterial whether the substances mentioned are introduced into syrups and into the system in heroic or homœopathic doses;

they can only do harm and should be kept out. Their medicinal properties make them unsuitable as constituents of food products and they are absolutely unnecessary. The only necessary preservative to guard against the spoiling of syrups is:

I. Sufficient body; a specific gravity not below 42° B.

II. Sterilizing when filling the containers.

III. Air-tight packages.

IV. Absolute cleanliness in the process of manufacture.

The largest manufacturers of corn syrups use these means, and only these to preserve their products.

The retail price of corn syrups is as low as 10 cents for a 2½ lb. can. There are very few food articles on the market today that are as cheap and pure or as wholesome and nourishing as the common corn or glucose syrups.

DETAILS OF AN EXPERIMENT IN COMPOSITION OF FORCES.

BY W. C. HAWTHORNE,

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In none of the elementary texts on physics with which I am acquainted are the conditions of equilibrium with parallel forces worked out completely by the laboratory method. It has been my custom to give the following directions for an experiment to be performed by the pupil, after having taken up a few preliminary ideas as to the effect and representation of force.

A STUDY OF PARALLEL FORCES.

Object.—To find the conditions of equilibrium when the forces are parallel.

Material.—A "checker board," twelve inches square, with rows of holes one inch apart each way. The horizontal rows are numbered, the vertical rows are lettered. Four spring-balances, registering to one ounce. A peg or nail, attached to the ring of each balance by a string ten or twelve inches long. By this means a force in any direction may be applied at any point on the board. In order that the board may move with little friction, it is mounted on marbles which rest on a smooth surface.

Directions.—Case I. Apply a force of 24 to the northward at C6

and a balancing force at F6. What is the line of action, the direction, and the magnitude of the balancing force? [Repeat if necessary until the pupils see that two forces in equilibrium must act in the same straight line, be opposite in direction and be equal in amount.]

Case II. Apply a force to the northward at C6 and a balancing force at C7 (?). At C8 (?). At C9 (?). What effect does it have on a force to change its point of application along its line of action?

Call forces to the northward plus; to the south, minus.

Case III. Balance a force of +24 at E6 by two negative forces, one at D6 and one at G6. By two negative forces, one at C6 and the other at G6. By two negative forces, one at C6 and the other at I6. What is true of the sum of all the forces, positive and negative in each trial? [Ans.—The sum of all the forces, positive and negative, acting upon a body at rest, must be equal to zero.]

Case IV. Imagine the board pivoted at C6, so that it may turn freely in either direction. Compare the turning effect produced by a force of +30 at D6 with that produced by a force of +30 at F6. With +15 at H6. With +30 at B6. With −30 at F6. With −30 at B6.

Define moment of a force. How is it found? If distances to the right of the axis are called positive and those to the left negative, show that a moment may be positive or negative, and give examples of each. Define positive and negative moments with reference to the motion they tend to produce, as compared to the motion of the hands of a clock.

Apply forces as directed below, balance them by other forces, and fill out blanks. Axis at B6.

HOLE	DISTANCE	FORCE	MOMENT
D6	?	+40	±?
C6	?	30	±?
G6	?	?	±?
Sum			

Calculate anew the *distances* (of forces from the axis) and the *moments* when the axis is taken at some other point, as H2. (Remember that the *distance* or *arm* of a force is the perpendicular distance from the axis to the line of action of the force.)

State law of moments of forces in equilibrium.

With the above work and its meaning firmly fixed in the pupil's mind, all problems concerning the lever and its applications are easily solved. The idea of couples may then be worked out for another experiment, when they have the final law governing the equilibrium of parallel forces: The sum of the moments of the couples must be equal to zero. By this principle many problems

may be easily solved that present difficulties when attacked by the law of the triangle of forces, as for instance the forces acting on the hinges of a door, the weight and dimensions of the door being given.

In conclusion, let me say that no originality is claimed for anything here, of course, but the method of presentation. This method has given good results in my classes.

THE CIRCULATION OF THE BLOOD.

BY W. H. MANWARING,

Johns Hopkins Medical School.
Formerly Professor of Physiology and Hygiene, State Normal School, Winona, Minn.

In a note in one of the recent numbers of this journal, a vivisection method was given for the demonstration of the circulation of blood in the web of a frog's foot. I believe, and believe most strongly, that anything approaching a vivisection method should be absolutely forbidden in the public schools. The anti-vivisection craze, that has caused so much inconvenience to medical research, was born and fostered from just such experiments, performed by unskilled teachers, before impressionable and immature pupils. There is only one place in elementary physiology where a vivisection method is necessary, and that is in the making and experimenting with a muscle-nerve preparation.

Not only is the resort to vivisection methods unnecessary in the demonstration of circulation, but circulation can be demonstrated much more easily and in a more striking way without it. Probably the easiest method is by the use of minnows. A very small minnow, if placed on a bit of moist absorbent cotton on the slide of a microscope, will generally remain quiet for some time, and the picture obtained by observing its tail or dorsal fin is one of the most striking the high-school student sees. The large arteries breaking up into smaller ones and these, in turn, into capillaries, the union of the capillaries to form the veins and these, the venous trunks, all can be seen in one field of view. When the observation

is over, the little fish can be returned unharmed to the aquarium, to be forever afterwards an object of intelligent admiration by the pupils, and there is no impression of cruelty and hard-heartedness on their minds, the impression that is the strongest when a pithed or chloroformed frog is used.

The picture obtained by the use of small, or even quite full grown tadpoles is nearly as striking. These can be laid flat on the slide and held in place by a little cage of wood or plaster of paris. But a method that always creates the deepest impression is the demonstration of the circulatory system in the chick embryo of from 36 to 72 hours. These can be obtained by incubating fresh eggs in the laboratory or by the use of hens. The eggs should be opened under warm, physiological saline (0.7 per cent NaCl 37.5° C.; pure water, of course, kills the embryo), and observed by the class. With a pair of fine dissecting shears the germinal disc can then be removed and floated out in a watch glass. Under the dissecting microscope and the low power of the compound microscope, the entire circulatory system can be studied. The action of the heart and the flow of the blood can be seen with perfect distinctness, and in a way that creates the most vivid impression, and one that can hardly be obtained by any other method.

These observations, coupled with experiments with the syringe-bulb model and a study of the anatomy of the sheep's heart, give a clear idea of the circulatory system, with no recourse to what the laity will always rightly consider cruel and heartless methods.

BALANCE DETAILS.

BY E. C. WOODRUFF.

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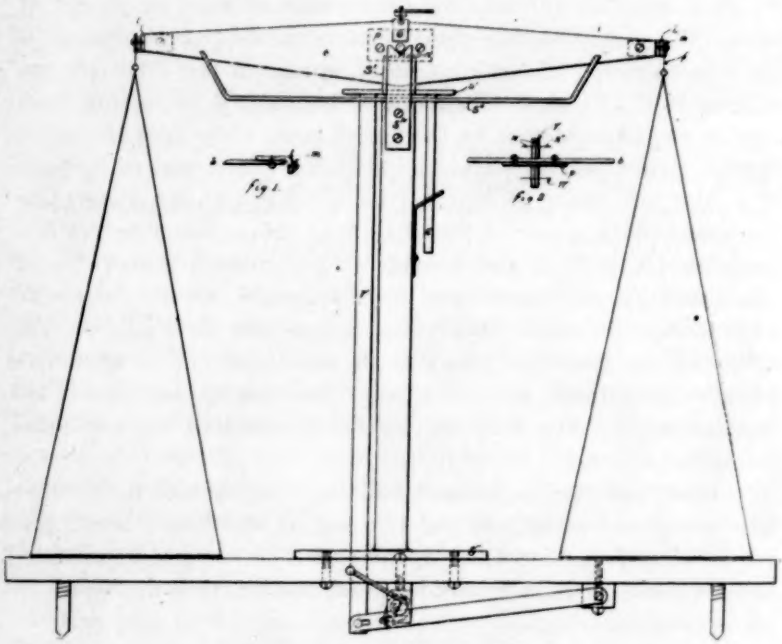
The following plan for a balance of any desired sensitiveness and accuracy, and yet of a construction involving no very difficult operations and but little expenditure for material and tools, is offered as a suggestion to teachers who may not be able to buy quite as good balances of the conventional kind as they may need.

The chief object in designing the balance was to eliminate knife edges, especially for supporting the pans, and to substitute something equally good for most work. Incidentally several other details in construction were simplified and brought within the powers of the man handy with ordinary tools.

The plan as drawn is taken from a balance in actual use, with but few changes in some minor details. The pointer is omitted



for the sake of clearness. The size of each part may be deduced from the length of the beam, 8 1-2 inches between pan supports. The beam is of 1-16 inch sheet aluminum, the pans and hangings from very thin aluminum sheet and wire. The remaining parts are all of brass, with the exception of the fiber base and the bearings for the beam and pans. Parts *r*, *r'*, *r''*, *r'''* and *r''''* are brass rods and tubes, 1/2, 1/4 and 1/8 inch in diameter. Parts *S'*, *S''*, *S'''*, *S''''*, *p*, *l*, etc., are of sheet brass 1/8, 1-16th and 1-32nd inch

in thickness. The standard, r'', is soldered to the base plate, S'''. The bent plate, S', which carries what corresponds to the agate planes in the conventional construction, is soldered to the lift and guide rods, r' and r'''. The bent plate, S'', is soldered to one of the plates S''''. S'' and S'''' receive the beam in four V-notches when it is lowered to change the weights. The mechanism below the base needs no explanation.

Taking up now the special features, the beam bearings and the pan supports, Fig. 1 gives a top view of the right hand pan support. Pinched between the plates l and m is a silk fiber or collection of fibers, f, and these fasten to the wires that support the pan. At one end the beam is slotted longitudinally so as to allow l to be adjusted to bring the points of flexure of the fibers equally distant from the beam bearings.

Fig. 2 gives a bottom view of the beam bearings and the parts of the lift in immediate contact therewith. n' and n'' are very fine cambric sewing needles. n' is soldered to the rod r, which rod is soldered to the plate p and fastened to the beam as shown. The needles, n'', are fastened to the edges of the U-shaped plate, S', and extend at right angles to n'. The radius of n' being very small, ordinary deflections do not change the relative lengths of arms of the balance appreciably.

The rolling friction between the supporting needles is so small and the resistance of the silk fibers to flexure is so slight, that the sensitiveness of the balance compares favorably with that of those having agate planes and knife edges. In ease of construction, adjustment and repair, and in stability in use, the knife edge construction is considerably exceeded. The balance from which the plan was drawn will easily give a deflection of two millimeters per milligram, and will carry a load of 200 grams.

Balances are in use constructed after the same general plans, but with the following modifications:

(1) One balance of six-inch beam and of a much lighter construction shows a deflection of ten millimeters for one milligram difference in load, and easily carries 50 grams in each pan. This balance represents a much more carefully made design than the first and is, of course, inclosed in a case.

(2) On the other hand, balances have been used with considerable satisfaction whose beams were of a close-grained wood, whose beam bearings were fastened to the top of wooden pillars, with no lifting mechanism, whose pan supports were held between L-shaped brass paper fasteners secured to the beam by wood screws, whose needles were about No. 3 in size; and yet they had a sensitiveness of 0.01 gram and a carrying capacity of ½ kilo in each pan, combined with a practicability and a minimum of cost that meant much when equipment was deficient.

These balances, and other pieces of apparatus involving the same kinds of bearings of crossed cylinders and flexible suspensions of fibers bending where they are pinched in a crack, have been in use now for nearly ten years, and have proved more than satisfactory, considering the ease with which they have been made, their stability in action, and the sensitiveness and accuracy of which they are susceptible.

A SPECTROMETER.

BY JOHN LE MAY.
Instructor in Physics, Lake High School, Chicago.

A spectrometer suitable for the laboratory work of most secondary schools may be constructed without excessive expenditure of either money or labor.

A circular table *A* of seven-eighths inch wood ten inches in diameter is fitted closely to a one inch brass tube seven and a half inches long. It is fixed in place by roughening the brass tube and gluing. A circular block *B* is used to make the support firmer. A six inch circle of wood *C* serves as a base. The whole is rendered more stable by filling the lower half of the tube with Babbitt or other expansive metal. The Babbitt metal should be cast into the tube before the wood parts are fitted on.

The rotating table *D* is a three inch circle of wood one half inch thick, with a one inch hole three-eighths of an inch deep on the under side, to fit over the top of the brass tube. A pointer *E*

of one-eighth inch brass rod extends to within one inch of the edge of the table.

The telescope support *G* is carried on a revolving arm *H*, shown in plan in Fig. 2. A cylinder of lead one and a half inches in

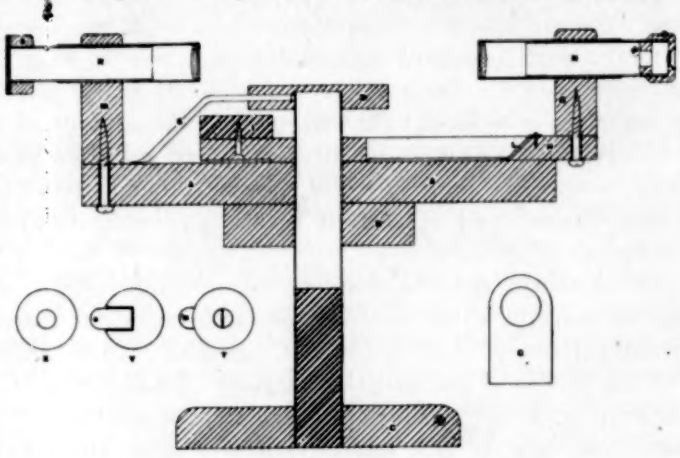


Fig. 1.

diameter and one-half inch high, *I*, serves as a counterpoise.

The telescope support *G* is fastened to the arm *H* by a single round-head screw one and a half inches long, the arm being bored to receive the shank of the screw. The support itself should be bored, to prevent splitting, with a hole somewhat smaller than the screw. An index *L* may be made of thin copper and screwed to the arm.

The collimator support *M* is similar to the telescope support,

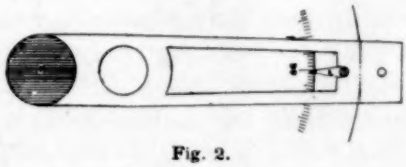


Fig. 2.

but it is half an inch longer, and it is screwed to the table, which is bored to receive the shank of the screw.

The telescope *N* consists of two three inch lengths of brass

telescope tubing, one thirty-second inch wall, three-fourths inch inside and outside diameters respectively, varnished inside with dead black varnish. The objective is a three-fourths inch achromatic lens, four inches focal length, cemented in position with shellac. The eyepiece is a five-sixteenths inch single lens, one-half inch focal length, cemented with shellac to a wooden ring *O* of cross-section shown. The ring *P*, fitting closely inside the draw tube, bears the cross hairs, which may be of human hair or very fine wire cemented in place with shellac. To set the cross hairs in position, remove the draw tube and, looking through the eyepiece toward a window, push the ring to such a position that the hairs are in focus.

The objective and tubes of the collimator *R* are similar to those of the telescope. The slit may be built up as shown at *S* and *T*. A cylindrical ring of wood *S*, one-half inch long, is fitted over the end of the draw tube and cemented in place. Pieces of a cartridge paper shaped like *X*, *Y* and *X* are glued on in succession. Care must be taken that no glue may get into the slot in which the slip *a* slides.

The wood parts may be varnished or painted black. The brass parts should be polished with fine emery paper, then warmed and laquered with white shellac dissolved in alcohol.

Eight inch circles on cardboard, divided to half degrees, are obtainable from dealers in draughting supplies. A one inch circle should be accurately cut in the center, to fit over the brass tube.

To adjust the instrument, first set the telescopes in line with each other and with the center of the table. Tighten the screws so that there will be no twisting of the telescope supports. Then focus the telescope on some distant object, and scratch the draw tube to mark its position. Place the telescope in line again, illuminate the slit and adjust the draw tube of the collimator until the slit is in focus. Mark the position of the draw tube of the collimator. Place the 0° line of the divided circle directly under the axis of the collimator, and cement the circle in position. With the cross hairs of the telescope on the image of the slit, adjust the index of the revolving arm to the 180° line, and the instrument is ready for use.

ELEMENTARY EXPERIMENTS IN OBSERVATIONAL ASTRONOMY.

BY GEORGE W. MYERS.

(*Continued from page 491, Vol. I.*)

Let the bolt at *C* be provided with a long, pointed head and fit a notched sight at *A*. Attach a plumb-line to the head, *C*, and allow it to hang freely in a vessel of water (battery cell or tin cup) supported by a stand, *S*, on the post, *EF*. Placing a carpenter's level on the top of *AC*, hold the quadrant so that the bubble will play, and start the graduations with the point which then falls just beneath the line near *B*, the graduations rising to 90 deg. at *A*.

If desired, a circular board, graduated and fixed horizontally to the post, *EF*, just below the stand, may be added, from which, by the aid of a pointer fixed to the post, *OM* or *PN*, horizontal angles, or azimuths, may be read. All measurements of altitude and azimuth which are made with a universal instrument may be roughly made by this apparatus, if the objects used are bright.

Experiment XXIV.

To make a wooden quadrant for hand use.

Join two ¾-inch surfaced boards together, reinforcing them by cleats, if necessary, and cut from them a quadrant of radius 18 inches, as suggested by the accompanying figure. Graduate it, and provide it with a plumb-line, as shown. By means of a handle attached as represented in the edge view, altitudes of naked-eye objects may be measured by hand, much after the fashion of the simplest forms of the sextant. The sight-line, *SC*, is determined by a notched sight at *S*, and a pin or nail at *C*. The graduation lying just beneath the cord at *D*, when the sight-line is directed to the object, furnishes the angular elevation of the object above the

*For the convenience of those who may desire to use these experiments (there are forty-four of them) in their clases, they may be obtained in pamphlet form from "The School Science Press," Ravenswood, Chicago, at 25 cents a copy, and $2.50 a dozen.

horizon. The reading may be very much facilitated by an assistant. Altitudes of the moon, of the brighter stars, and with the use of colored glasses to protect the eyes, of the sun may be

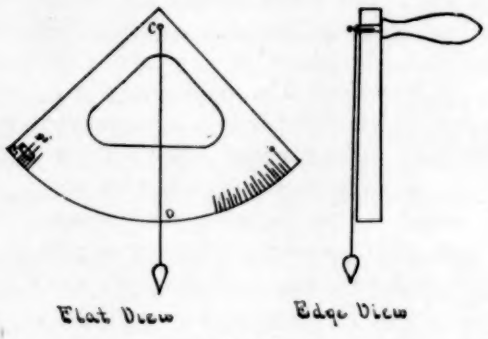


Fig. 24.

measured with rather surprising accuracy with this device, after a little practice.

Experiment XXV.

Construct a Tycho's quadrant.

If the quadrant, *ACBD,* of the last experiment be made smaller and lighter, and a pin be inserted at *C* to serve for a handle, the quadrant may be supported by hand. In this case an assistant observer will note the reading which falls under the plumb-line.

Experiment XXVI.

Construct a plumb-line gnomon.

Surface a board (*DE.* Fig. XXI), 2 feet by 3 feet, and fix two uprights, *A* and *B,* vertically upon it. Tie the uprights with a cross-piece, *C,* at the top, and suspend a plumb-line, provided with a sliding bead, from the middle of *C.* Varnish or paint the surface, and with thin wedges at *G* and *H* level the board carefully with a spirit level and mark the point just beneath the lower tip

of the bob. Hereafter the board may be leveled by sliding the wedges in and out until the bob hangs just over the designated point. With this point as a center, describe a series of concentric circles with radii varying by one inch (or by ½ inch). By noting the instant when the forenoon shadow of the bead crosses (or touches) any circumferences and the instant when the afternoon shadow crosses the same circumference, the time of apparent noon is given by taking one-half the sum (the mean) of the times of the two suggested instants.

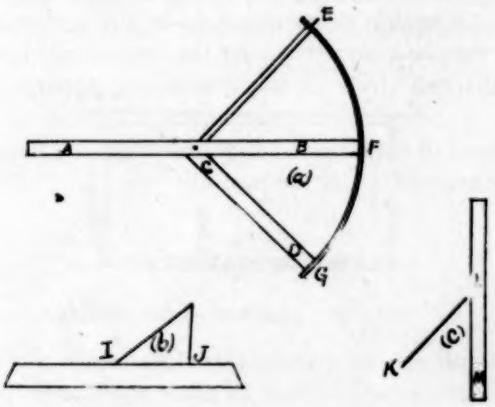
To find the meridian, see Experiment XX, (a), (2).

Experiment XXVII.

Construct a horizontal sun-dial.

Apparatus for graduating a horizontal dial.

Cut out and surface two wooden circles of 12 inches diameter and fit the half of one to the other at an angle of 48° (the



(a) = Graduating Apparatus,
(b) = Horizontal Dial,
(c) = Vertical Dial,

Fig. 25.

colatitude of Chicago). Erect at the common center of the circles a wooden or iron rod, making an angle of 42° (the latitude)

to the whole circle, and on the side opposite to the one on which the half-circle is fitted, as indicated in the figure. Cut the rod off to a length equal to the radius of the circles. Fasten one end of a flexible strip of copper, *EFG*, the length of which equals a quadrant of a circumference whose radius equals the radius of a circle, to the top end, *E*, of the rod, leaving it free to turn.

Graduate the circle, *CD*, whose plane is perpendicular to the rod, *CE*, 5° or 10°, then by putting the end, *G*, of the copper strip, *EFG* (free to turn about *E*), at the successive points of graduation of the circle, *CD*, corresponding points may be transferred to the circumference of the full circle, *AB*, which, being connected with bottom of the rod, will indicate the consecutive positions of the shadow of the rod for twenty and forty minute intervals of time. This completes the apparatus for graduating the dial.

To make the dial:

(a) Insert a smooth stick in a surfaced board at an angle with the surface equal to the latitude of the place. Describe about the foot of the stick a circle of radius of six inches and transfer to this circle, from the point directly under the end of the stick, the graduations of the full circle of the graduating apparatus described above.

(b) Instead of the inclined stick the edge of a triangle may be used, whose angle, *HIJ*, is the latitude.

Experiment XXVIII.

To make and graduate a vertical dial.

On the south side of a vertical surface attach a triangle (or a rod, *KL*, foregoing cut) so that its plane shall be perpendicular to the vertical surface, *LM*, and its hypothenuse, *KL*, shall make an angle equal to the co-latitude (90 deg.—latitude) with this surface.

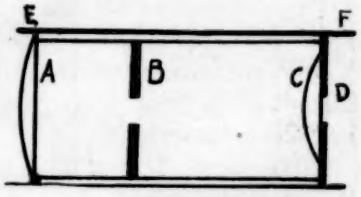
To graduate the circle *LM*, an apparatus like the one for the horizontal dial may be used, save that here the angle *E C F* must be the *co-latitude* (90 deg.—latitude), and the angle *F C G* must here be equal to the *latitude* of the place.

Experiment XXIX.

To construct a negative, or Huyghenian, eye-piece.

Procure two plano-convex lenses, one of $\frac{3}{4}$-inch diameter and 2 inches focal length, and the other of $\frac{3}{4}$-inch diameter and $\frac{3}{4}$-inch focal length. Roll up around a cylindrical stick, 5-8 inch diameter, heavy manila paper, using 6 or 7 ply, a cylindrical tube. The successive layers of paper may be stuck with library paste.

When the cylinder dries, cut off a piece of $1\frac{3}{8}$ inches, square the ends, and fit the lenses as suggested by the figure. Before attaching the lenses to the tube, cut from the center of two circular pieces of pasteboard a smooth hole $\frac{1}{4}$-inch in diameter, as at *B* and *D*. After pasting the edges of the first disk, stick it in the tube $\frac{3}{4}$ inch from one end, *D*, where the 2-inch focal lens is to be attached. The edges of the lenses may be stuck to the paper by means of gold-size. Complete the eye-piece as suggested by the cut. The completed eye-piece should be covered with a layer of tissue paper, the edges of which are allowed to extend beyond the ends of the tube, as shown at *E* and *F*. The ends should then be



Eye-piece.

Fig. 26.

stuck down around the edges of the lens, *A*, and of the pasteboard disk, *D F*.

(N. B.—This exercise is due to Dr. George Pyburn, and was published in *Popular Science Monthly*, Vol. XXIV., No. 1. The article is also reproduced as *Appendix A* in Miss Byrd's *Laboratory Manual.*)

Experiment XXX.

To make a telescope.

Obtain a 1½-inch x 30-inch achromatic object-glass, *O*, and roll up tubes of manila paper, stick with glue or library paste, and make a cell (as *c*) around it. Then roll up a tube, *T*, 30 inches long, and a draw tube, such as *D*, some 15 inches long. Provide the back end of the draw-tube with cardboard flange, *F*, and roll up smaller tubes to fit, as indicated in the figure. The collars, *G G* and *H H*, may be made by rolling narrow strips of manila paper about the tube, *A*, until they just fit inside *D*. A strip of broadcloth, just wide enough to wrap once around the outside of *a*, should be glued to the outer surface of *a* to insure smooth sliding of *a* within *A*. The eye piece was fully explained in Experiment XXVIII.

(See *Appendix A* of Miss Byrd's *Laboratory Manual.*)

(See Fig 27, next page.)

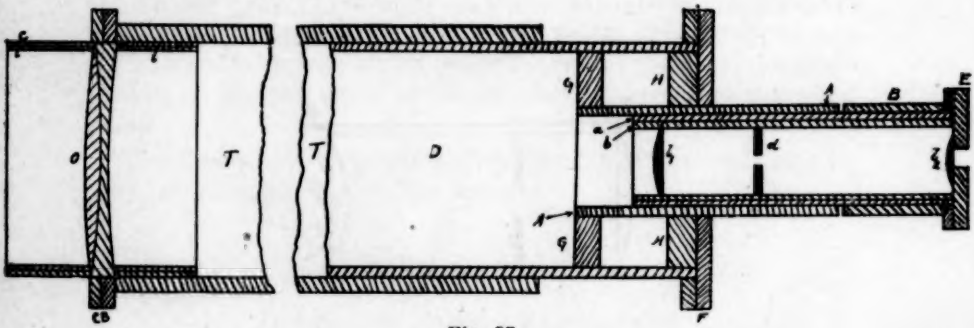


Fig. 27.

O.	Objective.	*B.*	Covering for eye-piece.
C.	Cell and cap.	*C B.*	Flange of Pasteboard.
i.	Inner tube to hold cell.	*F.*	Flange.
T.	Main tube.	*l1* and *l2.*	Eye-piece lenses.
D.	Drawtube.	*d.*	Shoulders.
a.	Eye-piece adapter.	*G* and *H.*	Perforated diaphragm.

(*To be continued.*)

Metrology.

DECADENCE OF THE VULGAR FRACTION.

BY RUFUS P. WILLIAMS.

(*Continued from page 405, Vol. I.*)

Opponents of the metric system argue that in the great marts of business, the chambers of commerce and stock exchanges, the tendency is away from decimalization. This is not true.

Stocks are quoted in whole numbers, quarters and eighths, because they have always been so quoted and there would be some little difficulty in changing at any given time, owing to adjustment of accounts on a new scale. In the continental bourses quotations of local stocks are in tenths, whereas shares of United States and English companies must be quoted as in their own exchanges or else reduced to parity. But while the quotations in our exchanges are expressed in eighths, the bookkeeper employs the decimal system in computation. Suppose the stock sells at 61⅝, the accountant writes 61.625, and if the customer buys 100 shares he writes 6162.50, thus changing aliquot parts to decimals, and saving much time. In some exchanges, like the New York Consolidated, this system is further accentuated by trading in multiples of ten shares only. Both these facts show a tendency to break away from the cumbersome old divisions. In most exchanges the only round lots are hundred shares or their multiples, and the par value is usually 100 or a decimal part of it.

The Cotton Exchange illustrates clearly the tendency referred to. Trading in cotton futures was not practised till after the close of the Civil War, spot cotton being quoted like other stocks in cents, halves, quarters, etc. When provision was made for quoting futures it was decided to employ the most modern method, and they have always been given in cents, tenths and hundredths, whereas spot cotton is to this day quoted by the old terms. Bookkeepers say it is easier to keep the accounts for "futures" than for "spot." Several other commodities, like pork, lard, coffee, etc., which

have lately been listed on the exchanges, are quoted only in decimals. The advance or decline in sugars, etc., when quoted at wholesale, is in cents, tenths and hundredths. Thus do the facts from the great business centers show the preference for decimalization in a very marked degree.

It remains to note a few of the facts and events of daily life in which records are kept in multiples of ten or in decimals of the unit: humidity, dew point, rainfall, sunshine, readings of barometer and thermometer, comparative average of crops, and crop reports of all kinds, sanitary conditions, mortality in general and in particular diseases, measurement of athletes, lifting and other capacities of strong men, comparisons of all sorts of athletic sports and events, transportation rates of grain, milk, etc., speed of trains and of vessels, rise and fall of tides and rivers, bank clearings, registers for street car fares, gas meters, vernier readings, and almost all automatic records of every sort. Stop watches record the fifth of a second—practically a decimal division. Reunions come on decades. We even record hours and minutes as though they were decimals.

The rooms of large office buildings of late construction correspond in hundreds to the floor number; for example, all rooms on the fifth floor are numbered from 500 up, and those of the sixth floor begin with 600, though the last room on the fifth floor may be 524. To some extent the same is done in street numbering, as between fifth and sixth street the numbers may run between 500 and 600. In many cities the numbering of residences and blocks is on a basis of ten, a new number being assigned to each 10 linear feet. This list might be continued *ad infinitum*. Take any newspaper and search for tables of comparisons on any subject whatever, and almost invariably you find fractions expressed decimally.

The only practical logarithmic base which has survived the last 300 years since Napier invented logarithms is the decimal one. Great importance is attached by teachers of arithmetic to the rapid mental solution of questions involving common fractions. Under existing conditions this is necessary; but it is questionable how great this value will be when the computations of daily life correspond still more nearly with those of the scientist and mathe-

matician. French arithmetics have far fewer common fractions and far more decimal than ours, and teaching in the schools of France is correspondingly simplified. The early arithmetics (as Pike's, 1788-1832) put great stress upon the superiority of Federal over English and other moneys. People are now so accustomed to this they forget that the advantages are no less when applied to measuring, weighing, and the other arts of life. As the banker in counting bills stops involuntarily at each ten to moisten his fingers, so counting by tens gets to be a habit in all intellectual efforts.

Such facts as these have a direct bearing on the metric system. Decimalizing the inch, the foot or the chain is a mere make-shift; the subdivisions created in the case of each are incongruous with the other two: 100 inches = 8.33 1-3 feet; 10 feet = 15 15-99 links; 1 link = 7.92 inches. The effort to introduce such decimalizations accentuates the desirability of a decimal scale acceptable to all peoples. What would be thought of a device—for example a gas meter or a car fare register—which recorded 12 on the lowest scale, 3 on the next higher, 5½ on the third, etc., after the manner of our linear measure, instead of a uniform scale ascending regularly by 10 or 100? The former scale could never for a moment compete with the latter, and no inventor or manufacturer would care to try the experiment. Can one reflect upon this fact and still believe that the metric system of weights and measures is not better than the one now in use?

NOTES.

The Metric Movement in Congress.—In response to a summons of Chairman J. H. Southard, several large manufacturers recently appeared before the House Committee on Coinage, Weights and Measures, to discuss the advisability of adopting the metric system. Among others was Prof. Elihu Thompson, of the General Electric Co., who presented the written views of many mechanical engineers, all of whom favored the adoption of the system. While he estimated the cost of change in the

General Electric Co.'s works at $150,000, he said this would eventually be saved in reduced cost of computations, etc.

Mr. James Christie, superintendent of the Pencoyd Bridge & Iron Works, the largest bridge works in the world, thought that $500 would cover the cost of change in his shops.

Mr. Troemner, manufacturer of scales and weights in Philadelphia, said that the only expense as regards common balancing scales would be in the change of weights, which, for the average country store, would not cost over five dollars.

Dr. A. E. Kennelly stated that electrical engineers dealt in units of the metric system to a large extent, and would be glad to have the system used in all branches of mechanics.

R. P. W.

In Parliament.—The Decimal Association has published a list of 229 Members of Parliament who favor the compulsory use of the Metric System and says there are 30 more who withhold their names, though in favor of the measure. This makes 259 Members favorable to the cause out of a total membership of 670 in the House of Commons.

R. P. W.

Notes.

BOTANY.

Reference has been made in these columns to the College Entrance Option in Botany, formulated by a Committee of the Society for Plant Morphology and Physiology. This Option has been adopted officially by the College Entrance Examination Board (of the Middle States and Maryland), and is published in their Document No. 8, issued Jan. 10, 1902. It was decided by the Society, at its recent meeting in New York, to publish a new edition of their Report containing the Option, and notice of its appearance will be given in School Science.

Smith College, Northampton, Mass. W. F. Ganong.

A Simple Wardian Case.—As no direct answer from anyone with experience has been received to the question (30) in the May, 1902, number of School Science, about a simple window case, we quote the following from Ganong's "Teaching Botanist":

"Have made a covered galvanized iron box the length of the window, two feet wide and three inches deep, with a hole in one corner

for filling, and a tight sheet-iron hood beneath to shield the flame and keep gases from rising through the joints of the case; have sashes made with as little wood as possible to surround and cover it 1....; on one of the long sides two doors must be left, which can be tightly closed; the top may be hinged to allow opening for ventilation at times; support the whole on a firm table; shelves of glass or wire netting may be added; use preferably a Koch safety burner (which shuts off the gas if the flame goes out) and a Reichert regulator. The entire cost should not exceed $25 to $30. It should not be built into the window, at all events not without an extra sash some inches from the window sash." Illustrations are also given.

GEOLOGY.

Many teachers of geology desire to present to their students an account of the past life of the earth in a manner that shall appeal to the greatest interest. Until now the remains of the vertebrate life of the past ages have been described in technical works largely, and either skeletons or very imperfect and inadequate restorations have been offered as illustrations. These are misleading or present no idea to the student of the animals' actual form; it is only in the last few years that it has been possible to restore the appearance of the forms with any degree of confidence in the accuracy of the picture. Recently two books have appeared from the press of D. Appleton & Co., which go a long way towards solving the difficulty. *Animals of the Past,* by Frederic Lucas, is a popular account of the life and habits, so far as known, of the most important or at least the most thoroughly known forms, and is well illustrated by drawings and photographs of models, mostly the work of Chas. Knight, of the American Museum of Natural History. *Dragons of the Air* is a somewhat more lengthy account of the Pterodactyls of the Mesozoic time. Perhaps no forms have more needed a clear and accurate describer to free them from the mass of monstrous structures that has been foisted upon them by uncertain describers, and in this book we have an account with good figures that may be depended upon as a step toward accuracy in representation.

Another book of very great value to the busy teacher of geology is a *Syllabus of Economic Geology,* by Branner and Newsom, Leland Stanford University Press ($2.75 by mail). This book presents in a very direct and clear fashion a good course in economic geology, and while it contains far too much to be given in the ordinary course in general geology, it will serve as a guide to the collection of the most

valuable material for presentation to a class. It is illustrated with many useful figures and diagrams.

In the October-November number of the Journal of Geology are two articles upon the principles of classification of the geological deposits. The first, by Prof. Bailey Willis, of the United States geological survey, deals with the individuals of the stratigraphic classification and is devoted especially to the value of the lithological characters of the deposits and their interpretation. The second, by Prof. H. S. Williams, has to do with discrimination of time values in geology and deals largely with the value of fossils as measures of time. A scheme of time description is proposed with new terminology. Both of these articles deal with the fundamental principles of classification of deposits and are of wide interest. An editorial in the same number promises a continuation of articles upon the same and related subjects and a full discussion. The next articles to appear will discuss the classification of minerals and rocks.

The address of the President of the Geological Society of Washington, Mr. J. S. Diller (SCIENCE, Vol. XV., No. 371), contains a description of the history and loss of the great mountain Mazama, which previously stood over the site of Crater Lake, Oregon, and presents the matter in the clear and direct style which has made Mr. Diller's work of the greatest use to teachers and students, notably the Bulletin 150 of the U. S. Geol. Survey, which described the collection of rocks prepared by the Survey for distribution. The address, entitled "The Wreck of Mt. Mazama," begins with a brief history of the Cascade Range. The states of Wyoming, Montana, Idaho, Washington and the northern portion of California, comprise what was in early Neocene time an active volcanic area, which is as large as any in the world. "The western limit of this great volcanic field is marked by the corresponding border of the Cascade Range, which is made up at least largely, if not wholly, of volcanic material, erupted from a belt of vents extending from Northern California to Central Washington. Lassen Peak marks the southern end of the Cascade Range, and Ranier is near the northern end. Beyond these peaks the older rocks rise from beneath the Cascade Range and form prominent mountains, the range itself occupying a depression in the older terranes."

At the end of the Cretaceous time the coast of Northern California, Washington and Oregon subsided and the sea reached the base of the Sierra Nevada Range and covered most, if not all, of the present site of the Klamath Mountains. In Washington it reached as far as Mt. Ranier, and in Oregon to the Blue Mountains. The Cascade Ranges rest upon a base of the Cretaceous rocks, in a depression which extends from the Klamath Mountains to the Sierra Nevada and the Blue Mountains. This region has not remained as a depression, but has been ele-

vated; but the Klamath and Blue Mountains and Sierra Nevada have risen so much more rapidly that a depression would appear, if it had not been filled with the great lava flows which formed the Cascade Ranges.

In Eocene times the area described was elevated and largely eroded, and then the western portion depressed as far east as Roseburg, Oregon. There was little volcanic activity during the Eocene.

During Miocene time the volcanoes reached their greatest activity; though there is no evidence that any are active at the present time, the features of post-volcanic existence are, still apparent in hot springs, solfataras, etc. Mount Shasta and Lassen's Peak probably remained active until the Glacial time.

The author then describes the appearance of Mt. Mazama as it probably was before its destruction and as it appears today. It was, in all probability, as high as Mount Shasta (14,380 feet), and of quite similar appearance. The character of the lavas and the probable history of growth are next reviewed, and the characters of Crater Lake are discussed in relation to the pre-existing peak. When the wreck of the mountain occurred, 6,000 feet were removed from the level above the edge of the caldera occupied by Crater Lake. Calculating the size of this cone and the contents of the caldera, an amount of material equal to 17 cubic miles has disappeared from the mountain. The author proposes two theories to acount for this loss: first, explosion, and second, subsidence. At this point, Mt. Union, eight miles southwest of Crater Lake, is cited as a volcano in which the hard lava of the neck has resisted the wear of the elements and stands up above the worn-down tuffa cone, which originally surrounded, and Mt. Thielsen (twelve miles north), as a volcano in which the lava subsided in the neck after the last eruption. The last of the two theories proposed is regarded as almost certainly the true cause of the loss of the top of the mountain, though no lava flow is known which would account for the lost material, such as occurs of the Hawaiian volcanoes when the surface of the lava in the neck is lowered.

The whole address is of the greatest value to students, and might almost be presented as a class exercise as it stands. It is especially valuable as supplementing the material already at hand upon Crater Lake. It is probable that the address will be published as a Bulletin of the Geological Survey, with maps and figures. This will be a very welcome addition to teaching material, and it is to be hoped that the edition will be sufficiently large that it will not be exhausted as quickly as was the author's Bulletin of the U. S. Collection of Rocks.

E. C. C.

Book Reviews.

Supplementary Readings in Physics; The Air; Energy—a Constant Quantity; The Molecule; Weight. By J. A. CULLER. 12x18 cm. 16 pages. O. T. Corson, Columbus, O., 1901. 5 cents.

"The aim in this series of pamphlets is to apply the principles, rules and formulæ of the text-book on Physics to the actual and practical work of man and nature. Most pupils after a hasty study of Physics come from school with many hazy notions about many of the most important principles of science, because their minds have not been directed to the principles applied.

"It is hoped that these papers will aid in securing a deeper interest, starting real thought, and setting up this connection between the book and actual transactions.

"The most important subjects in Physics will be developed after this fashion, and the plan is to have enough of these pamphlets as property of the high school so that, from time to time, they can be given out as these subjects are being discussed, and again taken up and preserved for future classes."

This enterprise of Supt. Culler, as outlined in the above quotation, has much to commend it, and it is to be hoped that subsequent numbers of the series will follow in rapid succession. It is also to be hoped that the author will apply to himself what he so well says on page 13 of the pamphlet on "Weight" and will make some use in the rest of the series of the metric system, which he so earnestly advocates.

Books Received.

Modern Chemistry—By Fredus N. Peters. Maynard, Merrill & Co., New York, 1901. 412 pages, $1.10

A Laboratory Manual of Physics—By Henry Crew and Robert R. Tatnall. The Macmillan Company, New York, 1902. xii and 284 pages, 90 cents.

The Wide World. Ginn & Co., New York, 1902. vi and 122 pages, 30 cents.

Northern Europe. Ginn & Co., New York, 1902. vi and 122 pages, 30 cents.

Reports of Meetings.

NEW YORK ASSOCIATION OF BIOLOGY TEACHERS.

The general aim of this Association is to discuss and, if possible, to determine the best methods of teaching botany, zoölogy and physiology in secondary schools.

The Association is in a most flourishing condition, several new members having been added during the past year. Three of the meetings in each year are held in Manhattan and two in Brooklyn, thus giving teachers from both parts of the city an opportunity to take part.

The fifth meeting of the Association for the year 1901 was held on Dec. 6th, 1901, at the Ethical Culture School, 109 West 54th street, New York City. Several new members were elected and three interesting papers were read. Miss Florence Slater (Flushing High School) read a paper on the "Teaching of Entomology in the Secondary Schools." The secretary is unable to report fully on the paper. Dr. George M. Donaldson (DeWitt Clinton High School) spoke of the "Social Aspect of the Teaching of Physiology in Secondary Schools." The pupil, through the analogy of cells and the body to organized society, may be taught the scientific principle of division of labor. Mr. H. R. Linville spoke on "Some Practical Hints on Class Work with Living Animals." He mentioned at the outset four requisites for profitable work with living animals: First, familiarity with the general habits of the animals in nature; second, the possession of an abundant supply of active specimens; third, a carefully planned set of observations to be made; fourth, a freedom from bias as to what ought to happen, and a quickness to notice and to use the thing that really does happen.

Profitable work can be done in secondary schools on at least the following living animals: Any protozoa, hydra, with small classes, earthworms, nereis, crayfish, grasshoppers, slugs and mussels, with very small classes, fish, frogs and tadpoles.

The normal visible activities of three animals, the earthworm, sandworm and crayfish, were then described with a view to showing that practically all the better known functions of these animals can be observed and partially explained by young students. Acids or other wholly inexperienced stimuli should not be employed, because they confuse the normal reactions.

Besides acquainting students with the habits of more or less unfamiliar animals, these studies may be used to make interesting comparisons with similar functions in the body of man, and also to help the

student to understand more clearly than they could otherwise the relation existing between structure and function.

The first meeting of the Association for the year 1902 was held on the evening of Jan. 31, 1902, at the home of Dr. E. F. Byrnes, 43 Hancock street, Brooklyn, with Dr. Maurice A. Bigelow in the chair. Two interesting papers were read, one by Miss E. F. Byrnes (Girls' High School, Brooklyn) on "The Pedagogical and Ethical Content of Biology in Secondary Schools," and another by Miss Marion Brown (Erasmus Hall High School, Brooklyn) on "The History of the Teaching of Zoölogy in the Secondary Schools of the United States. (Abstracts of these papers are given below.) The officers for the ensuing year elected at this meeting are: President, Henry E. Linville (DeWitt Clinton High School); vice-president, Miss E. F. Byrnes (Girls' High School, Brooklyn); secretary, George W. Hunter Jr. (DeWitt Clinton High School); treasurer, Miss M. F. Goddard (Peter Cooper High School).

THE PEDAGOGICAL AND ETHICAL CONTENT OF BIOLOGY.

(An abstract of Miss Byrnes' paper.)

The claim of biology to consideration as an "educational appliance" is based not only on its pedagogical content, but also on the furnishing of data, which are the foundation of the modern psychology and philosophy.

The careful observation of an animal or plant enables a pupil to form a "percept"—a distinct mental image. As soon as the pupil has studied several forms belonging to one and the same group, he learns to form a "concept" in the *type* form. His concept is an abstract representation of the various concrete illustrations of the group with which he is familiar. The fitting of a percept to the concept next involves comparison and leads to the formation of judgments by inductive reasoning.

The objective nature of the forms studied helps to secure interested attention, which, through interest, becomes involuntary toward the subject; and, moreover, it aids the pupil in memorizing.

Habits of observation increase the power of seeing and habits of forming concepts train the mind in distinguishing between essential characteristics and unessential details; hence the study is of value as a means of mental discipline. Moreover, because the scientific method requires proof in support of assumption, as a test of their truth, it inculcates an honest habit of thinking.

The chief educational value of nature study lies in its power to form "germ centers" of interest. The chief faculties appealed to in the child are powers of observation and imagination. In the consideration of adaptive modifications, reasoning is also called into play.

The best results, however, are to be obtained only by extended use

of the laboratory method. Even the imaginative faculty is powerfully stimulated by a contemplation of nature and the discovery of natural law.

The biological sciences are especially valuable in education as laying a foundation for the understanding of the newer psychology which bases its teachings on the Recapitulation Theory. Dealing as it does with the teachings of heredity, evolution and adaptation to environment, the study of biology may be considered essential for the elucidation of principles, which are not only important as scientific data, but may also be considered as full of moral significance.

THE HISTORY OF ZOÖLOGY IN THE SECONDARY SCHOOLS OF THE UNITED STATES.

(An abstract of Miss Brown's paper.)

The history of biology in the secondary schools of the United States covers about a century. Botany was first taught. Zoölogy was introduced about 1825, and its history may be divided into four periods: (1) 1825-1870, a period characterized by the natural-history phase of the subject taught according to the text book method; (2) 1870-1886, in which comparative anatomy was made the basis for work and the text was supplemented by verification by specimens; (3) 1886-1900, during which time comparative anatomy continued to be the basis for work, but real laboratory work was introduced and laboratory manuals were used; (4) from 1900 to the present time there has been a gradual tendency to combine the natural-history phase with the comparative anatomy of the two preceding periods according to the laboratory method and in connection with field work.

Text books are the surest indication of the tendencies of a period, and by means of them three general lines of improvement are to be noted: (1) progress in aim from the narrow ideal of religious and memory training to the broader conception of mental, moral and physical development; (2)) broadening of subject matter through the discoveries of eminent naturalists; (3) three stages in method, (*a*) narrative, (*b*) classification, (*c*) morphology, and at present the beginning of investigation.

Reported by GEORGE W. HUNTER JR., Secretary.

PHYSICS AND CHEMISTRY AT THE NEW YORK STATE SCIENCE TEACHERS' ASSOCIATION.

Continued from page 505, Vol. I.

At the session on Saturday morning, December 28, 1901, the first paper was read by Mr. R. J. Kittredge, Union Classical School, Schnectady, N. Y., on "The College Entrance Preparation of Students as Viewed from the Secondary Man's Standpoint." A very brief abstract is as follows:

There is no uniformity in the requirements in physics set by colleges,

but since most high schools offer enough physics to cover the Regents' course and the list presented by the National Educational Association, the requirements are not a hardship. In most high schools and many colleges, science has a secondary place. There is little or no correlation between the different sciences, too little time is devoted to science in comparison with the classics.

The student who wants science should be given the chance to study science as widely and deeply as he is now required to study classics. Science teachers should advocate a science course of four years in which physics has the place corresponding to Latin in a classical course. An especial effort should be made to plan and adopt as uniform a course as exists in the classics. The college requirements might be readily adjusted to fit such a liberal preparation.

Fewer sciences—not more than four—should be taught in secondary schools.

The second paper was presented by Professor Charles M. Allen, Pratt Institute, Brooklyn, N. Y., on "Chemical Laboratory Experiments and Notes." He said (in abstract):

Classes in chemistry should be provided with a set of laboratory experiments having the following specifications:

(1) The experiments should be suited to the facilities of the school's laboratory and adapted to the needs of the class instructed.

(2) They should be sufficiently strenuous to call forth the best efforts of the student, and they should not inform him of results which, with a reasonable effort, he could determine himself.

(3) The list should include the standard experiments, some illustrating the latest developments, and, in deference to the modern trend of elementary chemistry, it should contain some quantitative experiments.

(4) They should have interjected a series of questions directing the attention to the important parts of the experiment, and the answers to which demand earnest thought, and thus break up the baneful habit of mechanically following instructions.

(5) They should be entirely separate from the text book, so that the text book can be kept out of the laboratory.

Such a set of experiments can be provided by the teacher by means of mimeographed or hectographed laboratory sheets bearing experiments selected, modified, or originated by the teacher. The only practical note book, as many teachers have found out, consists of detachable sheets, collected in a binder. The instruction sheets, being bound in with the "accepted" experiment notes of the student, make a record of laboratory work which is complete and satisfactory.

Mr. Frank M. Gilley then discussed the topic "How to Meet the Problem of Teaching Physics by the Laboratory Method in Secondary Schools." Mr. Gilley illustrated his method of teaching the whole class at once in the laboratory by means of two experiments, a simple one in

reflection from a plane mirror, and a difficult one involving the Wheatstone bridge. He showed that effective work can be done by teaching certain experiments to a large number at the same time, provided sufficient apparatus is available and the experiments chosen are adapted to this method of presentation. This paper was followed by a general discussion.

Reported by LYMAN C. NEWELL.

EASTERN ASSOCIATION OF PHYSICS TEACHERS.

The thirty-second meeting of the Association was held at the Newton (Mass.) High School, Saturday, Feb. 22, 1902. There were thirty-two members and guests present. After the customary business, the secretary, Mr. F. R. Hathaway, read his annual report, which showed that the past year had been one of progress, especially in the publication and distribution of literature devoted to the teaching of physics. The annual report of the treasurer, Mr. George A. Cowen, revealed the fact that the Association is in a prosperous financial condition. The committee on current events, through its chairman, Mr. L. J. Manning, gave a summary of a dozen or more articles on physics, which have recently appeared in the magazines. Mr. F. M. Grunlau, Cambridge (Mass.) High School, was elected to fill the single vacancy. The following officers were elected for the ensuing year: President, Mr. Clement C. Hyde, Hartford, Conn.; vice-president, Mr. George W. Earle, Somerville, Mass.; secretary, Mr. N. Henry Black, Roxbury, Mass.; treasurer, Mr. George A. Cowen, Jamaica Plain, Mass.; three members of the executive committee, Mr. J. C. Packard, Brookline, Mass.; Mr. C. S. Griswold, Groton, Mass.; Mr. Charles R. Allen, New Bedford, Mass.

The business was followed by an informal address by Dr. F. A. Waterman, Professor of Physics, Smith College, Northampton, Mass., on "The Scope of an Elementary Course in Physics." The speaker called attention to the fact that the work offered for entrance to college is diverse. He attributed the diversity largely to the various aims of preparatory teachers, ranging all the way from utilitarianism to true natural philosophy. Both extremes are objectionable; the former because it emphasizes mere manual training, and the latter, while the nearer right of the two, is apt to lack practical value and scientific character. The aim in all preparatory work should be to teach a mean between these two extremes, a course which is really scientific. Such a course will select the best parts of all courses, it will arouse and hold attention, it will never be a series of mechanical processes nor a collection of dry theories. Its real nature will be to cultivate reasoning power. He said, in regard to improving the teaching in secondary schools, that teachers should constantly ask, "What am I doing this for?" A course should be called a failure, or at least very faulty, if students do not know its

object and aim. The teacher should constantly ask, "What is vital and what is incidental?" Such teachers have the proper perspective of physics. Again, improvement may be made by more careful thought regarding the ground to be covered. And here the aim of each teacher should be to teach the best course in the time and with the means available. Teachers should not retain poor courses simply because someone else seems to be making such a course successful. Teachers also should pay more attention to the order of presentation and to the relative importance of topics. More stress should be laid on mechanics, since it is fundamental, and special pains should be taken to make the whole course a unity, and not let it be a collection of different topics. The speaker concluded by mentioning the legitimate means of stimulating interest which he had found profitable. The first is a timely reference to history, such as a quotation from Gilbert or Boyle. The second is a constant account of contemporary investigations, laying especial stress on the object of the work. This makes physics a living subject and prevents students from studying it as if all had been said and done. And third, opportunity is constantly taken to emphasize the value of pure science; such work, for example, as is done by the German Reichsanstalt, and is soon to be done by our own National Bureau of Standards. In conclusion, the speaker, with pardonable enthusiasm, urged his hearers to teach constantly the fact that physics is a fundamental science and that no other science of equal value can be substituted for it.

After lunch, Mr. Charles R. Allen read a paper on "Gas Engines." The paper was illustrated by lantern slides and was an interesting and instructive treatment of the construction, operation and use of this kind of engine.

At the conclusion of the above program the members visited the factory of Stanley Brothers, manufacturers of the Stanley Automobile, and, through the courtesy of the firm, were shown the various parts, especially the motor, of this class of carriage.

Reported by LYMAN C. NEWELL.

NEW YORK PHYSICS CLUB.

The sixtenth regular meeting of the club was held on Saturday, Feb. 8, at Stevens' Institute, Hoboken, N. J., President J. S. Gibson in the chair. Before assembling for the regular meeting, the members inspected the different laboratories of the institute, especially the new Carnegie Laboratory of Engineering, which has just been completed and presented to the institute by Mr. Andrew Carnegie, of New York. This building contains, in addition to a large lecture room, reading room and offices, engines of various kinds, steam, gas and gasoline, and a complete equip-

ment for boiler and engine testing. At the meeting routine business was transacted, the constitution was amended so as to make eligible for membership any teacher of physics in New York or vicinity, also making the executive committee consist of the four officers and the retiring president. From the Committee on Apparatus, Mr. Jameson called attention to a form of apparatus, devised by Queen & Co., for illustrating the laws of accelerated motion. This consisted of an inclined plane of grooved metal, hinged and adjustable for different angles, fitted with an accurately turned ball. Electrical connections and a sounder made possible the time intervals involved. Mr. Ball, of Pratt Institute showed a simple and inexpensive form of oblique pendulum, which could be set at any angle, from the vertical to the horizontal, and by means of which all the laws of the pendulum could be demonstrated.

The club then listened to a lecture by Prof. Geyer, assisted by Prof. Ganz, both of Stevens' Institute, upon "Fluorescence," the lecture being illustrated by many interesting and instructive experiments.

Reported by R. H. CORNISH.

ASSOCIATION OF THE SCIENCE TEACHERS OF CENTRAL ILLINOIS.

The organization was effected in April, 1901, at a conference of high school teachers held at Bradley Institute, Peoria.

The object of the science association is to improve and adopt uniform courses in elementary science. To do this, committees have been appointed to outline the work and give lists of apparatus needed to conduct the course.

The chemistry committee reported at the meeting of last fall, and its outlines have been in use in some of the schools during the present year, where they have given very good satisfaction.

The complete reports of the biology and physics committees were made at the meeting held at Bradley Institute, Feb. 8th. These reports besides including an outline of the laboratory work in the different branches which should be considered a minimum for one year, included a list of the apparatus in three grades, with cost and catalogue number, so that a detailed description of the apparatus could be easily obtained. A list of reference books best suited to the ordinary high school was added.

These meetings have proved very profitable, as the conference is limited and every one has a chance to express his views and ask questions.

It is hoped in this way to obtain some definite results, which would not be obtained from the loose statements of requirements so often made by colleges and universities.

Reported by F. L. BISHOP.

Correspondence.

QUESTIONS FOR DISCUSSION.

Teachers are invited to send in questions for discussion, as well as answers to the questions of others. Those of sufficient merit and interest will be published.

36. *What is a good list of about a dozen quantitative experiments suitable for a class in high-school chemistry?*

Simple Solution—Chemical Solution—Solubility of Salts—Water of Crystallization—Neutralization—Law of Definite Proportions—Law of Multiple Proportions—Proof that the products of a chemical reaction weigh the same as the factors—The Immunity of manganese dioxide in preparation of oxygen from manganese dioxide and potassium chlorate. These experiments have been successfuly performed in Shortridge High School. See SCHOOL SCIENCE, May, 1901, page 144.

In addition, the following: Weight of a litre of air and of oxygen as given by Dr. Newell's "Experimental Chemistry," also equivalence of zinc, magnesium and aluminum from the same source. Also the weight of a litre of carbon dioxide. See SCHOOL SCIENCE, January, 1902, page 430.

It is not likely that all pupils will have time for all experiments, but each will be able to do some, and listen to the explanations of others.

GEO. W. BENTON.

37. *What cases of chemical arithmetic should a senior class in high school be required to master?*

Second semester pupils in chemistry ought to be able to handle, before the close of the year, the subjects included in such a book as Waddell's "Arithmetic of Chemistry,' up to page 68.

GEO. W. BENTON.